BUILDING AN INTEGRATED LEAN SIXSIGMA METHODOLOGY FOR MANAGING IT SERVICES

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1 ABSTRACT

Lean Six Sigma is being used in many industries to achieve dramatic performance improvements in their operations, maintenance, engineering and business processes. The purpose of this research is to implement an integrated Lean Sixsigma methodology for process improvement thereby reducing cost of software development improving profitability. The thesis begins with a review of literature of Lean, Six Sigma, Lean Six Sigma and their role in the software industry. The integration of Lean Six Sigma in the software domain is presented, followed by presentation of the results from an empirical investigation of Lean Six Sigma for software development. The empirical case study of software development is examined here for establishing the effectiveness of this methodology.

The research reflects the Lean Six Sigma application and implementation in the software industry, using the commonly used statistical and non-statistical and software engineering tools and frameworks used within software business; and determines the critical success factors (CSFs) for a successful Six Sigma initiative in the software/IT industry. The research brings out Lean Six Sigma, for achieving operational excellence, can, as it turns out, do more than simply improve processes. The research also brings out how it helps discovering innovation opportunities far beyond operations, enhance financial performance. The adoption of methodologies outlined here would enable Software companies to attain improvements in terms of cost, schedule and quality.

2 INTRODUCTION

Lean and Six Sigma are two systematic business process methods followed by organizations to successfully achieve the above statement – Increase Customer Value by eliminating waste, variation, and defects in organizational processes, products, and services while saving time and cost without capital investment. Lean Methodology aims to eliminate waste and maximize the customer value. Six Sigma Methodology aims to eliminate defects in the business process and maximize the quality, resulting in increased customer value. Therefore, both, Lean and Six Sigma together are proven methodologies that increase efficiency, effectiveness, quality resulting in continuous improvement to increase the customer value. Therefore, the objective of this research, in the field of quality management is the combination of Lean Six Sigma to bring you the best of both worlds. This combination can be synergistic for quality improvement in the booming service sector. This research attempts to help start and develop a journey towards an integrated Lean Six Sigma, Improving quality by capitalizing on an integrated Lean Six Sigma methodology - for the quality improvement in Software development.

3 PROBLEM STATEMENT

Lean Six Sigma teams help executives explore and address a variety of business

questions.

- How do we integrate Lean and Six Sigma methodologies in an Information Technology services context?
- How can this integrated Lean Six Sigma be applied to Information Technology services and service-based processes?
- How does implementation of Lean Six Sigma contribute to financial performance?

4 BRIEF LITERATURE REVIEW

4.1 IT SERVICES INDUSTRY

Services is one of the major components of Gross Deomestic Product in the developed economies, viz. USA and UK. It now constitutes the majority employer and source of income of the order of 75% of gross domestic product (Zeithaml et al., 1990; Zeithaml and Bitner, 2003; Hill, 2005). Regardless of the importance of services for the economy, the quality of services delivered by the vast majority of organizations is not of the level required by customers. Quality of service is essential to improve the customer satisfaction rate. According to research, customer satisfaction rates to be at an all time low (Fournier et al., 1998, p. 43; Fornell, 2008, pp. 1-30) in the USA. In the U.K, a 12 month study of British adults found 86 per cent complaining of having personally received poor quality customer service (Acland, 2005). Indicators suggest that the level of service quality is actually declining, with year-on-year service deteriorating by significant amounts (Dickson et al., 2005) which is the most worrisome.

Some service areas such as the IT Services has a great focus on cost efficiency that there may be even greater enforcement of Taylor's principles than in manufacturing with associated increased negative effects on staff morale, process performance and customer service (Ellis and Taylor, 2006). Increasing customer demands, competitive pressures and rising operational costs are beginning to force a dramatic rethink of the management of operations in this area (Allway and Corbett, 2002). Typically, IT services have been rendered in all the phases of the Software Development Life cycle or in one or more of the phases.

4.2 SOFTWARE QUALITY AND ITS SIGNIFICANCE

Software quality is often seen as an inexplicable and subtle topic; it is perhaps the most ignored subject in the arena of software development (Kenett and Baker, 1999). For many business leaders, software quality is often viewed as opulence; something that can be forfeited, if necessary, for added features and functionality, faster development, or lower costs. However, the quality of software is of paramount importance to everyone, including users and developers. Software companies are suffering financial setbacks because of fierce global competition, and hence they are trying to control costs (Phan et al., 1995).

Both practitioners and academicians agree that software quality improvement techniques lead to a reduction in software development costs and therefore, addressing quality of

software quality is essential and critical (Kan et al., 1994; Weinberg, 1996; Yang, 2001). For minimizing errors and improving overall software quality, abundance of tools, techniques, and philosophies have been developed (Parzinger and Nath, 1998). A number of quality standards, methodologies and frameworks such as ISO 9000, TQM, Malcolm Baldridge National Quality Award, Six Sigma, Capability Maturity Model (SEI-CMM), Capability Maturity Integration Model (SEI-CMMI), Team Software Process (TSP), People Software Process (PSP), People Capability Maturity Integration Model (P-CMMI) have been embraced by organizations to improve their products and services.

The rendering of service is a different activity than the making of products. While these process methodologies focus on the service segment of software development whereas the Information Technology Infrastructure Library (ITIL) is a definitive approach that focuses exclusively on Software Service Management. ITIL defines a process methodology as one of the best management practice for continuous service improvement with a focus on improving quality, reducing costs, improving effectiveness and efficiency of IT services for application support and maintenance in a Software development life cycle.

The challenge the software services industry faces is to consistently deliver quality while reducing cost and cycle time. Though the quality standards and processes described above can achieve certain levels of improvement, but continuous improvement thereafter will become difficult under these quality processes. Considerable research has been done to arrive at frameworks and methodologies which can be used for continuous improvement for any of the phases or the full life cycle of software development. Lean, Six Sigma methodologies has been implemented independently in practical scenarios and has been found successful over CMMi and ITIL processes respectively for complete SDLC and technical support scenarios. However, limited research findings are available use of integrated Lean SixSigma for continuous improvement in software development life cycles.

4.3 OVERVIEW OF LEAN MANAGEMENT

The pedigree of Lean Management can be traced to the Toyota production system (TPS), a manufacturing philosophy pioneered by the Japanese engineers - Taiichi Ohno and Shigeo Shingo.

However, it is well known fact that Lean Management's history is deeper. It was in Henry Ford's revolutionary mass-production assembly plants where many Lean practices first emerged. The success of Ford startled the whole world financially, industrially, and mechanically. Ford achieved high throughput, low inventories, and practiced short-cycle manufacturing as early as the late 1910s. Taiichi Ohno greatly admired and studied Ford's accomplishments in the overall reduction of waste at early Ford assembly plants. The roots of TPS were clearly linked to the Ford's system. The TPS is the birthplace of just-in-time (JIT) production methods, a key element of Lean production and for this reason TPS remains a model of excellence for advocates of Lean Management. Lean Manufacturing, in particular is a repackaging of the TPS.

Lean Production

The Lean production goals of eliminating waste (muda in Japanese), aligns all activities along the value stream creating a value that is known as perfection. Efforts focused on the reduction of waste are pursued through continuous improvement or kaizen events, as well as radical improvement activities, or kaikaku. Both kaizen and kaikaku reduce muda, although the term kaikaku is generally reserved for the initial rethinking of a process. Hence, perfection is the goal and the journey to perfection is never ending (Womack and Jones, 1996). Another element of Lean management is the reduction of variability at every opportunity, including demand variability, manufacturing variability, and supplier variability. Manufacturing variability includes not only variation of product quality characteristics (e.g. length, width, weight), but also variation present in task times (e.g. downtime, absenteeism, operator skill levels). Lean management attempts to reduce task time variation by establishing standardized work procedures. Supplier variability includes uncertainties in quality and delivery times. The reduction in supplier variability is often achieved through partnerships and other forms of supplier-producer cooperation.

Lean Quality Management

Quality management practices in lean production emphasize the concept of zero quality control (ZQC). A ZQC system includes mistake proofing (poka-yoke), source inspection (operators checking their own work), automated 100 percent inspection, stopping operations instantly when a mistake is made, and ensuring setup quality (Shingo, 1986). Typically, inspections are performed quickly using go-no go gages rather than more time consuming variable measurement methods.

Lean Methodology

Initially, the publication of the book, "The Machine that Changed the World"- the Story of Lean Production (Womack et al., 1990), started the diffusion of some Lean production practices developed by the most competitive auto manufacturers in the world (Sanchez and Perez, 2001). Thereafter, Lean production was studied in other industries (Moore and Gibbons, 1997), especially among the non-manufacturing sectors. Some scholars even suggested that rapid change industries have adopted lean production vs. mass production as a growth paradigm (Duguay et al., 1997). Owing to its increasingly wide application to other fields beyond the manufacturing process, the term Lean for short is commonly used.

The objective of Lean is to rapidly respond to changing customer demands and to create more value at a lower cost (Womack and Jones, 1996). To achieve this objective, Lean provides a systematic five-step methodology for a lean transformation in an organization.

1. Identify what the customer really perceives as value.
2. Line up value-creating activities for a specific product/service along a value stream while eliminating activities that do not add value.
3. Create a flow condition in which the product/service advances smoothly and rapidly towards the customer.
4. As flow is introduced, let customers pull value from the next upstream activity.
5. Finally, it speeds up the cycle of improvement in pursuit of perfection in which

perfect value is created with no waste.

Lean definitions and philosophy

Lean is an operational strategy oriented towards achieving the shortest possible cycle time by eliminating waste. Lean manufacturing is derived from the Toyota Production System. There are many definitions for Lean. Some include value added activities and waste reduction.

Lean is the "continuous elimination of waste". The key word is continuous. The journey to Lean is never ending. All systems have waste. Lean manufacturing classifies these into 7 or 8 categories. Waste is often called "muda", which is the Japanese word for waste. The waste is removed using the collection of Lean manufacturing tools. Once waste is removed from a system, all that remains is value added activities, which is exactly the customer's requirements and is willing to pay for.

Various other definitions include the following:

Ohno characterized the key objectives of Toyota's early management practice as "production efficiency by consistently and thoroughly eliminating waste," and "the equally important respect for humanity" (Ohno, 1988a).

In 1990, the researchers of the MIT International Motor Vehicle Program (IMVP) published The Machine that Changed the World: The Story of Lean Production. John Krafcik coined the term "Lean Production" to describe an approach that used less of everything—less manufacturing space, tooling, raw materials, inventory, and labor—and did it significantly faster and cheaper than traditional mass-production techniques.

In 1996, James Womack and Daniel Jones published Lean Thinking, which outlined five principles that they believed a lean organization embodied throughout the enterprise: Value, identifying the value stream, flow, pull, and perfection.

The word "Lean" implies "cutting the fat" or "trimming waste", where "fat" or "waste" refer to whatever is not valued by the customer. So another way of expressing the "Lean Manufacturing" goal is to only use materials and processes that add value for the customer.

Lean definition has given many forms according to the views of authors and practitioners. It is obvious that a Lean System cannot be explained in a single sentence. But Lean can be defined generally as "a system which aims in elimination of the waste from the system with a systematic and continuous approach".

Lean Implementation

Changes occur in the economy rapidly. The modern economy is no longer based on mass production and consumption of goods and services. In this changing environment, producing more ± however efficiently ± is not necessarily better (Fornell et al., 1996). Hence, the current trend towards downsizing in firms may increase productivity in the short term, but the downsized firms' future financial performance will suffer, if repeat business is dependent on labor-intensive customized service.
In order to compete in this new economy companies must have:

- Quality beyond the competition
- Technology before the competition and
- Costs below the competition (Watson, 1993).

In other words, many companies must strive to be better, faster, and cheaper than their competitors. These are some of the characteristics of a Lean enterprise. In order to implement an organizational strategy successfully, managers must have a clear idea of several diverse issues. Some of the issues posed are:

- How much change is required within an organization?
- How best to deal with the organization culture in order to ensure smooth strategy implementation?
- How strategy implementation and various types of organizational structures are related?
- What are the different implementation approaches to be followed?
- What managerial skills are necessary to implement organizational strategy successfully? (Certo and Peter, 1993).

The Development of Lean Service

Womack and Jones (1996) proposed a major role for Lean improvement in the service sector and many researchers and practitioners have echoed their call for lean adoption in services sector (Abdi et al., 2006; Atkinson, 2004; Corbett, 2007; May, 2005; Ehrlich, 2006).

While Bowen and Youngdahl (1998) highlighted early on Lean approaches such as work redesign, increasing training, and a focus on process mapping in retail, airline, and hospital management could generate positive results for companies. Their investigation was based not on explicit Lean improvement but more on general change in principles, many of which share similarity with aspects of Lean thinking.

The key focus area of Lean service was not on the handling of commercial products but handling of patients in healthcare systems. One focus of research has been on the purchasing or supply chain inputs to the healthcare system, applying Lean supply partnership and inventory reduction approaches to improve responsiveness and cost (Jones and Mitchell, 2007; Kollberg et al., 2007). The greater body of research focused on the movement of patients through the treatment process. This research has treated patients as products, being moved through a transformation (treatment) process inside the healthcare system. Similar to a product progressing through an assembly line, patients (materials) were seen as entering the operation, undergoing operational activities performed on them such as admission, initial assessment, treatment regime, and so on, with an output being produced - a person cured or otherwise. This perspective, while not without critics, has allowed the use of established Lean tools such as mapping techniques and waste reduction (Seddon, 2003; Womack and Jones, 2005a).

Maintaining competitiveness requires continuously improve productivity, “doing more

and more with less and less". Continuous improvement is the life-blood for an organization's success. Proven methods from manufacturing provide effective solutions for the service sector. Eliminating non-value adding steps, while reducing response times to internal decisions and external requests, dramatically improves operating efficiency.

Several researchers have noted the extension of Lean into pure service, administrative areas as an extension of shop-floor level manufacturing change. These have included office systems such as order-receipt, quotation, sales processing, accounting, or human resources all of which has been found to be possible to improve with the application of the same Lean principles and basic tools of manufacturing (Juroff, 2003; Holmes, 2007; Demers, 2002).

The application of Lean approaches in the service sector has been underway for several years (Bowen and Youngdahl, 1998; Abdi et al., 2006; Atkinson, 2004). However, Lean approaches have predominantly been limited to service contexts where a physical product exists (such as retail supply chain management) or to healthcare.

Limitations

Greater research is still needed to verify real lean application in the pure service sector. Lean application in this environment is still emerging, with a focus on a small volume of projects, on one or two specific aspects of the lean toolkit and with different interpretations of Lean. There is a need for further examination of the explicit and direct application of Lean principles of operation to the pure service environment.

ROLE OF LEAN IN IT SERVICES

IT organizations spend enormous on infrastructure, maintenance, upgrades, administration, and so on. Lean approach in IT will enable organizations to achieve accurate business agility, cost reduction, and quality service.

Lean principles, traditionally used by manufacturing companies to help improve the production process and provide value to the customer, are now being implemented in more service-oriented domains. But the question is do principles that originated from manufacturing have a place in the IT? By exploring traditional IT operations and the wasteful practices it often employs, the answer is most definitely: yes.

Lean is first and foremost about the elimination of waste and that there is plenty of waste in IT, hence there is applicability for Lean in IT. To add on, IT is supporting broader business needs and therefore there is magnified waste in IT, which includes the following:

- Defective waste: Systems not meeting requirements, software bugs, missed deadlines, blown budgets, substandard project execution, and so on. This clearly adds cost to IT with poor customer service.
- Overproduction: Unnecessary working on low-impact squeaky wheel projects that really don't provide value to the business leads to increased cost with resource misused.
- Waiting: Slow application response, manual procedures, complex approval process, waiting for new hardware, waiting for software upgrades, and so on

reduce production and revenue.

- Non-value added processing: A good example here is IT keeping track of excessive amounts of technology metrics, and then reporting those metrics to business managers. Again, the old business / IT alignment demon rears its head. Unnecessary reporting to managers leads to miscommunication.
- Transportation: Excess data movement, software audits, on-site visits to resolve hardware and software issues leads to higher capital and operational expenses.
- Excess inventory: Unused or outdated software licenses, under-utilized hardware, benched development teams reduces productivity and increased costs.
- Excess motion: Unnecessary processes, recurring IT infrastructure problems results in low production.
- Unused employee knowledge: Un-captured ideas/ innovation, knowledge retention problems, low morale leads to talent leakage, low job satisfaction and increases support and maintenance costs.

Taken individually, each one of the above IT waste elements can have a detrimental effect on business operations.

According to McKinsey & Company—applying Lean IT principles can increase application development and maintenance productivity by as much as 40%, while improving the quality and speed of execution. Why? Because the characteristics of an application development department are similar to those of a factory or production line, and each category of waste in manufacturing has a counterpart in application development (for example: rework due to application code bugs or overproduction from fulfilling enhancement requests that aren't immediately necessary). Also, application development has a number of activities which should be automated and linked to remove waste across the entire line and increase the flow of production. Similar thinking needs to be applied in the area of IT operations, because like application development, IT operations can manage from a service lifecycle perspective; employing techniques and methods to better design, operate, and transit business services in support of a broader business strategy.

Applying Lean in IT is an attempt to resolve the problems arising out of IT waste elements, cost-effectively. Lean principles helps in creating new IT service models and switching from company-owned IT hardware, software and services to per-use based models. It focuses on reducing the IT infrastructure and related liabilities to reduce total cost of ownership. It focuses on changes in IT services and payment models to achieve desired business agility and flexibility without any software, hardware, and vendor lock-in. It also focuses on achieving guaranteed quality-of-services from various service providers.

4.4 OVERVIEW OF SIX SIGMA

Six Sigma Pedigrees

The root of Six Sigma is traced to two primary sources: Total Quality Management

(TQM) and Six-Sigma Statistical Metric originating at Motorola Corporation. Today, Six Sigma is a broad long-term, decision-making business strategy rather than a narrowly focused quality management program.

From TQM, Six Sigma preserved the concept that everyone in an organization is responsible for the quality of goods and services produced by the organization. Other components of Six Sigma that can be traced to TQM include the focus on customer satisfaction when making management decisions, a significant investment in education and training in statistics, root cause analysis, and other problem solving methodologies. With TQM, quality was the first priority. The main tools of TQM included the seven tools of quality: control charts, histograms, check sheets, scatter plots, cause-and-effect diagrams, flowcharts, and Pareto charts; and the seven management tools of quality: affinity diagrams, interrelationship digraphs, tree diagrams, matrix diagrams, prioritization matrices, process decision program charts, and activity network diagrams (Sower et al., 1999).

The six-sigma metric was developed at Motorola in 1987 in response to sub-standard product quality traced in many cases to decisions made by engineers, when designing component parts. Traditionally, design engineers used the "three-sigma" rule when evaluating whether or not an acceptable proportion of manufactured components would be expected to meet tolerances. When a component's tolerances were consistent with a spread of six standard deviation units of process variation, about 99.7 percent of the components for a centered process would be expected to conform to tolerances. That is, only 0.3 percent of parts would be nonconforming to tolerances, which translates to about 3,000 non-conforming parts per million (NCPPM).

At Motorola, as products became more complex, defective products were becoming more commonplace while at the same time customers were demanding higher quality. For example, a pager or cell phone included hundreds of components. Each component typically included numerous important quality characteristics. It was not uncommon for a product to include thousands of opportunities for defects (OFDs) in each product sold (Harry and Schroeder, 2000). Traditional three-sigma quality for each OFD was no longer acceptable. For example, consider a product that contains 1,000 OFDs. If, for each OFD, three-sigma quality levels are achieved, only about 5 percent of the products would be defect free. The calculation used to obtain this probability requires raising the fraction conforming (0.997) to the power of 1,000, and is based on the binomial probability distribution (Devore, 2000).

The formula used to determine the probability of defect-free products provides only an approximate guideline for two reasons. Since three-sigma is the minimum design standard, it would be expected that many products would surpass the three-sigma standard. On the other hand, the 0.997 conformance probability assumes a centered process and it would be expected that many processes would not be centered every time a component is produced. The calculation does, however, effectively illustrate the challenge inherent in producing defect-free products. Assuming 1,000 OFDs, only 37 percent of products will be free of defects if the quality level at each OFD averaged 99.9 percent and 90 percent of products will be free of defects if the quality level at each OFD averaged 99.99 percent.

Other industries face similar challenges in achieving superior quality. In addition to the

consumer electronics industry, other products with a large number of OFDs include automobiles, engines, airframes, and computers. Many industries where products are less complex also face similar challenges. Manufacturers of medical devices and other products where defects in the field may cause harm must achieve almost perfect quality. Companies that manufacture less complex products but sell them in very large volumes also need to be focused on achieving superior quality.

In late 1999, Ford Motor Company became the first major automaker to adopt a Six Sigma strategy. At Ford, each car has approximately 20,000 OFDs. Therefore, if Ford were to attain Six Sigma quality, approximately one car in every 15 produced would contain a defect (Truby, 2000). It is interesting to note that if Ford operated at a 5.5 sigma level, about 50 percent of their cars would include at least one defect.

Today, Six Sigma is a combination of the Six-Sigma statistical metric and TQM, with additional innovations that enhance the program's effectiveness, while expanding its focus. The main components of Six Sigma retained from TQM include a focus on the customer, recognition that quality is the responsibility of all employees, and the emphasis on employee training. The Six-Sigma metric is also used, but in an expanded fashion.

With Six Sigma, the value of an organization's output includes not just quality, but availability, reliability, delivery performance, and after-market service. Performance within each of the components of the customer's value equation should be superior. Hence, the Six-Sigma metric is applied in a broad fashion, striving for near perfect performance at the lowest level of activity. In addition, Six Sigma programs generally create a structure under which training of employees is formalized and supported to ensure its effectiveness. All employees involved in activities that impact customer satisfaction would be trained in basic problem solving skills. Other employees are provided advanced training and require to act as mentors to others in support of quality improvement projects.

What is Six Sigma?

The term sigma is a Greek letter used to describe standard deviation and is applied as a statistical process technology measure in organizations. Six Sigma stands for Six Standard Deviations from mean. This methodology provides the techniques and tools to improve the capability and reduce the defects in any process. Six Sigma methodologies improve any existing business process by constantly reviewing and re-tuning the process.

As stated by Breyfogle (1999), a sigma quality level offers an indicator of how often defects are likely to occur in the process considered, where sigma levels and corresponding defect levels are as derived from the standard probability curve for an organizational process.

SIX SIGMA IN SERVICES

"Six Sigma is every bit as applicable to service processes as it is to manufacturing."

Dan Mailick, VP of Six Sigma, JPMorgan Chase. Since its development by Motorola in the late 1980s, six sigma has gained considerable attention, especially since its adoption by high profile companies such as General Electric (GE) in the mid-1990s, six sigma has spread like "wildfire" (Caulcutt, 2001; Goh, 2002; Chakrabarty and Tan, 2007). Many

organizations in manufacturing and services, public and private, large and small have joined the six sigma band wagon. In addition to Motorola and GE, many other Fortune 500 companies such as American Express, Boeing, Caterpillar, Fidelity Investments, Honeywell International, J.P. Morgan Chase, Johnson and Johnson, Kodak, Lockheed Martin, Maytag, Northrop Grumman, Sony, and Texas Instruments have applied six sigma to myriad of projects. The six sigma waves have spread from the US to the European Union, Japan, and Canada. It is also gradually becoming popular in India and other less developed countries in Asia, Middle East, and Latin America (Thawani, 2004).

There is a growing number of descriptive and prescriptive articles, mostly authored by practitioners and consultants, that deal with six sigma applications in the service industry (for example - Biolos, 2002; Hensley and Dobie, 2005; Antony, 2006; Chakrabarty and Tan, 2007; Antony et al., 2007). Some researchers employ conceptual models to investigate the organizational requirements for effective six sigma implementation. Hensley and Dobie (2005) propose a conceptual model for assessing organizational readiness for Six Sigma and utilize the model to analyze the readiness of a public transit company based on survey data. Chakrabarty and Tan (2007) examine the current state of six sigma application in services based on quantitative and qualitative analysis of the literature and identify critical success factors and key performance indicators as management guidelines for effective applications of six sigma in the service industry. Biolos (2002) prescribes ways how to effectively implement six sigma in service organizations.

Six sigma success factors

Some studies have investigated the success factors for implementing six sigma in world-class organizations (Eckes, 2000; Antony and Banuelas, 2002; Antony, 2006; Antony et al., 2007). Antony (2006) highlights the six sigma success factors: strong leadership and management commitment, organizational culture change, aligning six sigma projects to corporate business objectives, election of team members and teamwork, six sigma training, understanding the DMAIC methodology, tools, techniques and key metrics, selection of projects and project management skills, linking six sigma to customers, and accountability (tying results in financial terms to the bottom line). Wessel and Burcher (2004), Antony et al. (2005), and Fahmy (2006) discuss the application of six sigma in small and medium enterprises and what can be done to help them succeed. Antony et al.(2007) report on the benefits, challenges, and critical success factors of six sigma projects in service organizations. While the majority of articles pertain to six sigma applications in the USA, several studies focus on a variety of countries (Wessel and Burcher, 2004 – Germany; Ho and Chuang, 2006 – Taiwan; Kumi and Morrow, 2006; Antony et al., 2007 – UK; Kim, 2006 – S. Korea; Pheng and Hui, 2004 – Singapore).

Biolos (2002, pp. 3-5) and Antony (2006, pp. 239-241) provide useful advice for consideration when applying six sigma to a service business:

- consider which processes can yield the most benefit from six sigma
- the customer comes first so you must consider the impact on your customer
- search relentlessly for the root causes

- get to the root cause of the main problems plaguing your process
- determine what is considered a service defect and how it will be measured
- compare your company and your company's capabilities before and after six
- sigma was implemented
- do not forget this is no short time commitment
- determine the risks that need to be considered with the project
- identify the costs as well as benefits associated with each part of the project
- clearly determine what everybody's responsibilities are as well as any milestones

The literature on six sigma applications to services is vast and varied. However, something seems to be missing. While the importance of linking Six Sigma to customer satisfaction is often mentioned in this literature, there is little analysis of what customer satisfaction is and the role customer expectations may play in the evaluation of quality. There seems to be little room to incorporate, or even provide linkages to, the relevant research in the service quality literature.

Limitations

In none of the articles on six sigma applications to services that we investigated did we find the recognition of a service quality model or the development of a theoretical service framework; in only a few (e.g. Hensley and Dobie, 2005; Kim, 2006) there was a brief reference to the service quality model. It appears that the application of six sigma to services will be severely limited if there is no deep understanding of the nature of services and of how people judge quality in services.

ROLE OF SIX SIGMA IN IT SERVICES

Today, some of the largest IT service organizations are looking trim. It is not a miracle, cure or diet of the month. It is a particular piece of process methodology called Six Sigma.

Six Sigma starts from a practical problem, translates it into a statistical domain, works out a statistical solution, and then translates it back to a practical solution. Sigma is a statistical unit of measure, which reflects process capability of any process. Sigma value is perfectly correlated to such characteristics as defects-per-unit, parts-per million defective and the probability of a failure/error.

Six Sigma methodologies objectives are:

- Focuses on customer and is based on data.
- Integrates with other software quality initiatives like CMM and CMMI.
- Is measurable, unlike other quality systems.

- Is an effective approach for removing defects from products?

Six Sigma is based on two basic methods:

- DMAIC - Define, Measure, Analyze, Improve, and Control
- DMADOV - Design for Six Sigma (DFSS) follows the DMADOV method - Define, Measure, Analyze, Design, Optimize, and Verify

The success of Six Sigma in the manufacturing domain has been reported all over the world. A report from the Black & Decker Corporation illustrates this. In January 30, 2003, the company announced that, despite the weak economic conditions, by focusing on Six-Sigma in the process of restructuring, operating profit for the Power Tools and Accessories segment increased 38% from the fourth quarter a year ago (Appliance Magazine.com, 2003).

Six Sigma is a disciplined, data-driven approach, and methodology for eliminating defects in any process—from manufacturing to transactional and from product to service. It is a measurement-based methodology that focuses on process improvement and variation reduction. It is based on the organized application of a set of statistical/analytical and problem solving tools/techniques.

For an industry that changes so often, IT services are unusually concerned with using a process like Six Sigma for process improvement. They have their own solutions, no matter how tedious they might be, and this causes many companies to balk at something they don't think they need.

Software development processes can be fully characterized by three simple measurements (Janieszewski and George, 2004):

- time – the time required to perform a specific task;
- size – the size of the product produced; and
- defects – the number of defects, the type of defects, time to eliminate defects, and so on.

However, Six Sigma within the IT industry can actually create a continuous improvement process for companies, allowing them to spend less time fixing errors one by one and more time doing things that are productive for the organization. Problem solving is the purpose of many IT services in the first place, and Six Sigma simply serves to enhance that purpose.

Implementation Challenges

Six Sigma aims to align business products within customer specifications using a data-driven approach. However, a software product is essentially intangible until it reaches system integration and test phase. There are difficulties in applying Six Sigma to the software industry, due to its statistical foundations in manufacturing and assumptions on process variation. Another barrier to the successful application of Six Sigma to software is a lack of adequate product and process metrics (Janieszewski and George, 2004). In addition, software development is a cognition-intensive activity and a software process

itself is an intellectual process; one must first visualize and document it, for example, before one can measure and manage it. However, Six Sigma does not specifically address this situation (Card, 2000; Hong and Goh, 2003; Hong and Goh, 2004). The fit between Six Sigma and software project management methodology is not always obvious. Some of the common Six Sigma tools do not easily lend themselves to software projects. Part of the reason is possibly that engineering and manufacturing have evolved over hundreds of years, software development is only a few decades old (Aggarwal, 2004).

A total of 90 percent of the processes in a software services company are repeatable and can be improved by the process improvement. Success of Six Sigma in the manufacturing domain has encouraged its application in the software domain. In 1999, SEI survey of high maturity software organizations, showed that among the 36 top maturity organizations surveyed worldwide out of the millions, only seven organizations institutionalized the Six Sigma practice as part of the organization's standard software process and four organizations followed it frequently (Paulk et al., 2000). Less than 20 percent of 194 companies monitoring software quality stated that they use Six Sigma to improve the quality of internally developed applications (Information Week, 2003). In a survey carried out in the UK software industry out of 15 companies that responded to the Six Sigma survey, ten companies were applying the principles of Six Sigma. The companies participating in the survey regarded requirement analysis as a potential area to improve followed by operation, maintenance, and testing (Antony and Fergusson, 2004).

Six sigma definitions and philosophy

Six sigma is often defined as a quality improvement program with a goal of reducing the number of defects to as low as 3.4 parts per million opportunities or 0.0003%. This has a number of different meanings and interpretations (Henderson and Evans, 2000). Its origin comes from statistics where sigma represents the amount of variation about a process average.

Sigma is the Greek letter that statisticians use to define a standard deviation from a bell curve. The higher the sigma, the fewer the deviation from the norm--that is the fewer the defects. At one sigma, two thirds of what-ever is being measured falls within the curve. Two sigma covers about 95 percent. At six sigma, you are about as close to defect-free as you can get.

From a business perspective, six sigma may be defined as: A business strategy used to improve business profitability, to improve the effectiveness and efficiency of all operations to meet or exceed customer needs and expectations (Kwak and Anbari, 2006).

Qualitative analysis of six sigma case studies in services

Although different terms may be used, scrap and rework exist in services just as they do in manufacturing. Inconsistent and out-of-specification processes cost money to rework. Such examples in services may include the need to re-contact a customer to verify an order, redress in providing an incorrect service, providing a substandard service, or even over-servicing or providing more than what is required (Does et al., 2002). Some widely publicized success stories due to implementation in services include GE Medical Systems, Mount Carmel Health System, Virtua Health, GE Capital Corp, Bank of

America, and Citibank (Jones, 2004; Henderson and Evans, 2000, Rucker, 2000). Limited application can also be found in call centers, human resources such as DuPont de Nemours (Bott et al., 2000; Wyper and Harrison, 2000), and in product support services such as by Caterpillar (Schmidt and Aschkenase, 2004). The analysis also revealed that the applications are limited mostly to service industries in North America and Europe. Benefit-wise, these are mostly expressed in financial terms and not much is published about the benefits in process improvement terms. Also important to note is that the applications emphasized the proper identification of critical success factors (CSFs), critical to quality (CTQs), and key performance indicators (KPIs). These factors are now discussed.

SIGNIFICANCE OF SIX SIGMA IN IT

Software development for business critical systems has emerged as a core discipline that every company has to perform. Software projects are often positioned at the critical interface between a company's products and/or services and the company's customers. However, software projects are associated with a high degree of risk. About 25 percent of software projects are cancelled because they are late, over budgeted, have unacceptably low quality, or experience some combination of these problems.

A Standish Group survey of 8,000 software projects found that the average project exceeded planned budget by 90 percent, its schedule by 120 percent, and project cancellation of 25 percent due to some combinations of delays, budget overruns, and poor quality. Requirement failures (reflecting needs not originally recognized or correctly understood, leading to substantial and costly rework late in the software development cycle) are associated with 80 percent failed (late or cancelled) software projects. Execution failures (incorrect and overly optimistic estimates, leading to long delays and cost overruns) are a factor in 65 percent of failed software projects. Execution failures (leading to poor software quality, heavily back-loaded costs, and very high levels of rework – commonly 40 percent of total cost) are a factor in 60 percent of failed software projects.

A division of Hewlett Packard decided to release its product despite a continuing incoming defect trend during the test phase. This resulted in a costly update after the release, a steady need for defect repairs and a product with a bad quality reputation (Grady, 1996).

Nowadays software is performing more critical tasks than ever before. Software failures in mission critical systems often jeopardize public safety. A discovery by Britain's nuclear regulatory agency that a power plant scheduled to begin operation was potentially unsafe due to inadequate software designed to manage the reactor in the event of an emergency (Schwartz, 1996). Software failures have caused disasters in the past. In February 1991, a software failure in Patriot missile's radar system allowed an Iraqi Scud to penetrate their air defense system and slam into an America barracks in Saudi Arabia, killing 28 people during the Gulf War (Schmitt, 1991).

The above points accentuate the necessity to decrease defects in complex and mission critical software. The benefit of Six Sigma to mission critical systems is rather significant. Owing to the extremely high costs involved in achieving the Six Sigma

standard, it is unlikely that a software development team will achieve a true Six Sigma level. However this doesn't diminish the value of Six Sigma and having minimal defects as a goal. However, software failures can cause customer dissatisfaction which may result in software companies losing business to their competitors (Hong and Goh, 2003). Although, the true statistical meaning of Six Sigma that is 3.4 defects per million opportunities does not hold, in this case. Six Sigma for software is more about using the methodology to achieve "continual process improvement" than it is about achieving a statistical Six Sigma process output.

4.5 INTEGRATION OF LEAN AND SIX SIGMA

Summary

Lean Methodology can be summarized to:

- Minimize inputs and wasted outputs.
- Maximize throughput of any process.
- Start a process to meet the customer's requirements
- Produce the correct customer requirement at the first time
- Establish "continuous improvement" in every process

Six Sigma Methodology can be summarized to:

- Select projects to maximize financial improvement but define a limited project scope
- Look at the problem from the customer's point of view
- Investigate and document the business process, including inputs and outputs
- Use statistics: take samples and analyze the variations
- Minimize variations to ensure repeatable quality

Comparison

Over the last two decades, American industrial organizations have embraced a wide variety of management programs that they hope will enhance competitiveness. Currently, two of the most popular programs are Six Sigma and Lean management. Six Sigma was founded by Motorola Corporation and subsequently adopted by many US companies, including GE and Allied Signal. Lean management originated at Toyota in Japan and has been implemented by many major US firms, including Danaher Corporation and Harley-Davidson. Six Sigma and Lean management have diverse roots. The key issue driving the development of Six Sigma was the need for quality improvement when manufacturing complex products having a large number of components, which often resulted in a correspondingly high probability of defective final products. The driving force behind the development of Lean management was the elimination of waste, especially in Japan, a country with few natural resources.

Blending the Methodologies- Lean Six Sigma (LSS)

Michael George defines the principles of Lean Six Sigma as: "The activities that causes

the customer's critical-to-quality issues and create the longest time delays in any process offer the greatest opportunity for improvement in cost, quality, capital and lead time".

Bill Carreira defines the Lean Six Sigma concept as: "Lean Six Sigma is about relentless, sustained improvement – analysis after analysis, metric after metric, and project after project, lean causes products to move through processes faster, and Six Sigma improves quality".

The basic concept is to add Lean's "continual improvement" as an ongoing activity to the completion of every Six Sigma project. In this way, Six Sigma moves away from a "project that was completed" to a "process that is ongoing". Continue to gather data to feed Six Sigma's statistical analysis. Continue to seek incremental improvement by empowering the front-line workers to make their suggestions. Using the Lean "continuous improvement" approach, workers can make changes. Ongoing statistical monitoring provides the data Six Sigma needs to evaluate the success of these changes.

Both Six Sigma and Lean management have evolved into comprehensive management systems. In each case, their effective implementation involves cultural changes in organizations, new approaches to production and services, a high degree of training and education to employees from upper management to the shop floor. As such, both systems have come to encompass common features, such as an emphasis on customer satisfaction, high quality, and comprehensive employee training and empowerment.

With disparate roots but similar goals, Six Sigma and Lean management are both effective on their own. However, some organizations that have embraced either Six Sigma or Lean management might find that they eventually reached a point of diminishing returns. That is, after re-engineering, the operating and supporting systems for improvement, by solving major problems and resolving key inefficiencies, further improvements are not easily generated. These organizations have begun to look elsewhere for sources of competitive advantage. Naturally, Lean organizations are examining Six Sigma and Six Sigma organizations are exploring Lean management. The term Lean Sigma has recently been used to describe a management system that combines the two systems (Sheridan, 2000). In this research, the term Lean Six Sigma (LSS) organization will be used to describe an entity that integrates the two systems.

4.6 FLEXIBILITY FRAMEWORK: MANAGING CONTINUITY-CHANGE

Cost reductions, faster time-to-market, better products and differentiated services are now the important pillars in managing any software development process. Cost reduction and seamless productivity improvement by ensuring optimal developmental cost are becoming more relevant that before. In this changing business environment, software engineering approach is undergoing a shift from the traditional Software Development Life Cycle (SDLC) approach to newer models that can provide higher predictability and risk reduction by ensuring that business deadlines are met. Recently the germination of the idea about combining Lean methods with Six Sigma approaches for continuous improvement has attracted the attention of academia and industry. The continuity forces are normally associated with the 'processes', whereas the change forces largely emanate from 'flexibility' (Sushil, 2001). Six Sigma is representative of *continuity* forces and

Lean is representative of the *change* forces.

In simple terms, flexibility is the opposite of rigidity. Flexibility is the ability to adapt to new, different or changing requirements (Sushil, 2000). Flexibility in Lean management is a measure not of a sub-system but of an entire value stream from the end customer through the supply chain and back to the end customer (from request to fulfilment). A Lean measure of flexibility entails planning and capacity building that is based not on forecasts but on real customer demand (Volberda, 1998). Thus, it represents the ability of this value stream to deliver consistently every product within commitment date.

5 RESEARCH OBJECTIVE

Rendering best Customer Service is the main objective of any service organization. Lean Six Sigma methodology enables this objective to be achieved successfully. Embracing this methodology enables the organization to better identify and meet the customer needs by emphasizing creative problem solving and teamwork. It also focuses on continuous improvements where performance is constantly evaluated, re-tooled as needed, and enhances the overall financial health of the organization. Lean Six Sigma provides a service-based approach, explaining how companies of all types can cost-effectively translate manufacturing-oriented Lean Six Sigma tools into the service delivery process.

Michael George - expert in Six Sigma reveals how easy it is to apply relatively simple statistical and Lean tools that will reduce costs and achieve greater speed in service processes.

To summarize, any service organization by embracing Lean Six Sigma can:

- Reduce waste and costs
- Improve communications
- Improve service and experience
- Achieve greater customer satisfaction

The objectives of the research are:

1. to explore the possible benefits of integrating the lean and Six sigma paradigms into a comprehensive framework
2. to expand the usefulness of above integration in a non-manufacturing context, such as a service sector
3. to illustrate the practicality of such integration in a specific industry, namely software services industry
4. to reduce costs by improving the operational efficiency through cycle time reduction and defect reduction
5. to bring out the management dilemmas in integrating the change-continuity duality in an IT environment

6 PROPOSED METHODOLOGY

6.1 LEAN METHODOLOGY

Waste in an Organization is like a fog which conceals the truth, making the process slow and inefficient. Lean is a process control methodology that continuously focuses on the elimination of waste, smooth process flow, and reduction of cycle times resulting in optimum customer satisfaction. The core concepts of this methodology are:

- The process must not deliver anything which is not valuable to the customer.
- The process must not deliver anything until it is needed by the customer.
- Improve the Quality by reducing the waste and cost, and optimizing smooth process flow.

Lean evolved primarily in the Japan and U.S. automobile industries. Although, the earliest examples of employing the underlying pillars of Lean dates back to the 16th century (more on this later), Lean was originally developed by Toyota as an assembly-line manufacturing methodology known as the Toyota Production System. Implementing Lean production enabled Toyota to minimize inventory, maximize the use of multi-skilled employees, flatten the management structure, focus resources where they were needed, and deliver on demand. Toyota also focused on reducing system response time to quickly change and adapt to market demands. This move resulted in their made-to-order automobiles. Toyota finally through Lean succeeded in producing top quality cars at low prices.

The current model for Lean Manufacturing was developed and refined by Toyota in the 1940s, 50s, and 60s. In 1990, James P. Womack, Daniel T. Jones, and Daniel Roos published “The Machine That Changed the World”, which introduced the term Lean to describe the set of attributes that embodied the Toyota Production System. During the 1980s, Lean methodology was adopted by many manufacturing companies across U.S. and Europe. For example, Dell Computers and Boeing Aircraft have embraced the philosophy of Lean production with great success.

Today, Lean or at least some of its most popular concepts are used in all types of industries including the non-manufacturing companies. Lean history has come a long way to bring us here. Thus, Lean can be summarized as "to get the right things to the right place at the right time, the first time, while minimizing waste and being open to change".

6.2 SIX SIGMA METHODOLOGY

Defects are defined as unacceptable deviation from the mean or target. Six Sigma is a well structured data-driven methodology to manage the process variations that cause defects and eliminate these defects. The objective of Six Sigma is to deliver high

performance, reliability, and value to the end customer. The concepts of this methodology are:

- Continuous efforts to achieve stable results by reducing process variations.
- Process performance must be measured, analyzed, improved, and controlled.
- Achieve sustained performance and quality improvement.

Six Sigma has evolved over time. This methodology was pioneered by Bill Smith at Motorola in 1986. It was initiated as a statistically based method to reduce variation in electronic manufacturing process in Motorola. Six Sigma helped Motorola achieve powerful results at reduced cost. Since then, hundreds of companies around the world, with an aim to reduce cost and improve quality have adopted Six Sigma. Texas Instruments, Scientific-Atlanta, and Allied Signal are a few of the companies that practice Six Sigma.

The Greek letter sigma is sometimes used to denote variation from a standard. The philosophy behind Six Sigma is that if you measure the number of defects are in a process, you can find a method to do systematically eliminate them and get as close to perfection as possible. To achieve Six Sigma, the defects per million opportunities cannot be more than 3.4 where an opportunity is defined as a chance for nonconformance.

6.3 INTEGRATED LEAN SIX SIGMA METHODOLOGY

Although Lean and Six Sigma are different business management strategies to achieve business excellence, both these strategies needs to be combined, having one without the other results in process destruction. The combination of both the methods brings you the best of both worlds.

Lean Six Sigma combines process improvement with quality. While Lean implements rapid business process, the problem of errors in the process is reduced by using Six Sigma. Lean and Six Sigma together, promise to address all types of process problems with the most appropriate toolkit. Lean Six Sigma delivers faster results by establishing baseline performance levels and focusing the use of statistical tools, where they will have the most impact. Lean Six Sigma combines the strategy and solution sets inherent in Lean with the cultural, organizational process, and analytical tools of Six Sigma. It is a methodology that, when properly implemented, ensures organizational effectiveness and efficiency. Usually, for companies using Lean Six Sigma, the first step is to apply basic Lean-manufacturing techniques and eliminate waste.

A significant organization-wide culture shift has to be rolled out to achieve bottom-line strategic business results by implementing Lean Six Sigma. A process focus–rather than a task focus–environment has to be developed; the scope and endurance for any service improvements will be limited. To succeed and understand the basics of customer-centered organization, "Delivery of right Service at the right time" must be the main motto while training the organization members. Service Industries must aim in providing their members with diligent training programs on Lean Six Sigma tools and methodology required to achieve long-term service improvements.

- Helps in the speedy delivery of quality products and services at reduced cost resulting in high customer satisfaction – a key ingredient to achieve improved performance and sustain competitive advantage in businesses.
- Cultivates innovation and places more emphasis on continuous process improvement.
- Identifies key drivers of economic profit and shareholder value to create project portfolio.
- Develops broad cultural change and creates a common operational language.
- Builds long lasting organizational capability to create and sustain a process-performance advantage.
- Eliminating waste not only reduces costs but also results in rapid business and more response to customers, increasing the revenue growth.

Thus, Six Sigma and Lean complement each other to provide the best operating performance possible. Operating excellence is a key global driver of economic profit with analysis revealing that 30-80% of the costs in a service business are pure waste. Never ending elimination of waste and high-quality driven business processes through the integration of the proven improvement methodologies Lean (Speed) and Six Sigma (Quality), organizations can address strategic priorities and transform operations.

6.4 FLEXIBILITY FRAMEWORK: MANAGING CONTINUITY-CHANGE

Flexible Management is one strategy for maximizing profitability at project level, organization level which includes lean manufacturing and Lean Six Sigma. Flexible management strategies are incorporated by a business to make defect free products/ models in a shorter cycle time (Lasserre, 2003). This often involves methodologies viz. Lean, Six Sigma, and can help make a system more profitable by utilizing it more efficiently.

In order to deliver better quality and reduced cycle time, Lean Six Sigma strategy must remain completely flexible dealing continuity and change. This flexibility may indicate the necessity for employing methodologies and tools that deliver optimum results for every stage of the Lean Six Sigma process (George, 2002).

Lean is an effective tool in eliminating wastes in production by handling the change forces. Lean methodology is designed to maintain a continuous flow of products in order to flexibly adjust to changes in demand. Lean effectively deals with the change forces which are external forces of demand by minimizing all forms of waste, thereby just in time production is achieved, quality and productivity are increased while unit costs are decreased.

Six Sigma focusses on defect reduction by reducing process variations. This is achieved by systemically controlling the internal forces through identifying problems, defining goals and conducting root cause analysis. Continuity is concerned with internal forces and control of performance of the process is achieved using Six Sigma by institutionalising improvements and monitoring on a constant basis.

This thesis introduces a framework that holds together the aspects of continuity and change under a flexible management system and illustrates the application of the continuity - change framework using an integrated Lean Six Sigma for software development in a practical context.

7 RESEARCH ANALYSIS OF THE CASE STUDIES

A case study approach is being taken up to evaluate the implementation of Integrated Lean SixSigma for software development. As part of this research two empirical cases have been attempted, one for a full life cycle of software development and the other for an application technical support.

7.1 CASE STUDY 1: FULL SOFTWARE DEVELOPMENT LIFE CYCLE

This case concerns with the implementation of Lean-Six Sigma for a software development project which has all the phases of the Software Development Life Cycle. The software is essentially a web based Global Physician Polling Application that is developed to enable administrators to create Physician surveys based on client requirements. The application shall also enable manage the Physician registration, review and payment status reporting.

Global Physicians Panel application is proposed to be built by CDM to manage information collected from a Global List of Physicians. Information is collected from the Physicians using Surveys created by the administrator/s of the application based on the requests from clients. Physicians are compensated for their participation in the Survey. This compensation may be paid directly to the Physician or to a charity selected from the list of charities available within the application.

We use here the methodology defined by Su et al. (2006) in the empirical study on "Improving service quality by capitalizing on an integrated Lean SixSigma methodology" from a Flexible Management system standpoint. In this case, the Integrated Lean SixSigma is implemented to pursue perfection over the CMMi processes implemented for software development. The objective of the case study is defect reduction and cycle time reduction thereby achieving cost savings.

7.2 CASE STUDY 2: SOFTWARE APPLICATION SUPPORT

In this case study, we attempt application of Lean SixSigma methodology, as a case for continuous improvement after implementing the ITIL processes for IT Service management by conducting a practical study on a Software application support project and analyse the benefits.

The current study focusses on a case for an SAP application support taken up for one of the leaders in providing catering and provisioning services for airlines and railroads. The client name is not revealed due to confidentiality reasons. SAP is implemented across the organization to manage the operations across the organization which include airline solutions, product and supply chain solutions. This is an empirical study conducted on

continuous improvement of the application support provided to this customer. The case study is attempted to evaluate the improvement service delivery by consistently meeting the SLA norms at reduced cost and improving the customer satisfaction.

8 RESEARCH OUTCOME

There are two different cases attempted as part of the research from a software development life cycle viz, a pure development project with a complete life cycle and also a support project which has implemented ITIL.

8.1 CASE STUDY 1: FULL SOFTWARE DEVELOPMENT LIFE CYCLE

One of the major findings in this case was that the cycle time is reduced considerably to the order of 10-12 % equivalent compared with the performance before implementing the Lean Six Sigma methodology, and it also reduces the defect density by 32%. This achievement in cycle time reduction implies that the Lean Six Sigma methodology has proven its power to accelerate the process flow by eliminating the non-value-added steps while also streamlining the remaining value-added steps.

Using Six Sigma framework, this project achieved a 3.4-sigma quality level result combining both hard and soft savings valued at over US$ 20,000 annually, based on the calculations of the obtained data. The hard savings refer to the Six Sigma project benefits that allowed this firm to do same amount of business with a fewer employees or handle more business without adding people. On the other hand, soft savings are Six Sigma project benefits such as reduced time to market, cost avoidance, improved employee morale and other intangibles, which contributed additional savings to the firm.

8.2 CASE STUDY 2: SOFTWARE APPLICATION SUPPORT

In this case, at first glance, ITIL and Lean Six Sigma appear to be mutually exclusive. However, as this paper discusses and the improvement project validates, these two approaches are highly complementary and can be used in combination effectively to continually improve business processes. The benefits are compelling:

- Reduce costs by helping to minimize potential downtime and the adverse effects of system, network, and application failures and install, move, add, change and decommission implementations.
- Enhance decision-making ability by facilitating access to information throughout the organization, and by enabling the enterprise wide use of outputs from an integrated framework of processes and tools through such devices as cross functional IT service dashboards.
- Improve IT service levels by creating operational efficiencies and enabling a linked IT Service Management process loop for defining, measuring, analysing, improving, and controlling service performance.

9 CONCLUSION

Combining the advantages of speed and consistency, the productivity level could be substantially improved and cycle time is considerably reduced. These considerable benefits highlight the competences of the Lean Six Sigma approach. The study attempted two different scenarios one for a full software development life cycle and the other for one of the phases. Both these cases have brought out quantifiable improvements through effective implementation of the Integrated Lean Six Sigma in a continuity-change paradigm.

While this study concentrated on the topic of applying Lean Six Sigma to software development and application support, there are many other potential areas such as Software Testing which deserve future research to explore the consistency of the continuous improvement and effectiveness of a Lean Six Sigma strategy in a flexible framework.

10 THESIS ORGANIZATION

The tentative organization of the thesis is detailed here. This thesis will comprise of seven chapters. The first chapter is an introductory part which includes the motivation, general introduction about Lean and Six Sigma followed by need for an integration of these two methodologies, and importance of Lean Six Sigma in IT Services. Following this introductory part is an insight into the Literature Review of IT service industry, software quality, broad overview, role, development, and significance of Lean and Six Sigma methodologies in service industries. Significance of these methodologies in service industries has been supported by successful stories. The third chapter discusses this thesis's research design and methodology. A case study approach is arrived at and the Problem statement, issues and complexities are brought in this chapter. The implementation of LeanSixsigma is discussed and a discussion on the benefits derived is included in Chapter 4. Incorporating Flexibility in Continuity – Change paradigm is detailed in Chapter 5. The research analysis and findings, summary of these findings, and conclusion to adopt the integrated Lean Six Sigma have been described in the last two chapters.

1. Introduction
2. Literature Review
   2.1 State of Art (Lean, 6 sigma, Combination)
   2.2 Various conceptual frameworks according to different authors
   2.3 Integration issues, methodological difficulties in implementation
3. Case studies
   3.1 Problem Statement
   3.2 Issues and complexities
4. Implementation of Lean six sigma

4.1 Details of implementation
4.2 Benefits derived
5. Proposed Framework incorporating flexibility
5.1 Lean Sixsigma integrated model
5.2 Continuity - Change paradigm
5.3 Integrating flexibility
6. Generalisation
6.1 Generalisation to other Software life cycles
6.2 Generalisation to other contexts
7. Conclusion

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